

We claim:

1        1. A method for chemical mechanical polishing of tungsten comprising:

2              providing a semiconductor substrate comprising on one face tungsten and a dielectric  
3 material;

4              providing a chemical mechanical polishing composition comprising between about 2%  
5 and about 15% ammonium persulfate, between about 0.1% and about 10 % of a secondary  
6 oxidizer, a pH adjusting compound to adjust the pH of the composition, and optionally an  
7 abrasive, wherein the pH of the composition is between about 6.5 to about 12;

8              movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9 psi pressure on the substrate and with the composition under conditions that tungsten is removed  
10 at a rate different than the removal of the dielectric material.

1        2. The process of claim 1 wherein the secondary oxidizer comprises potassium  
2 peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or malonamide.

1        3. The process of claim 1 wherein the chemical mechanical polishing composition  
2 comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1        4. The process of claim 1, wherein the chemical mechanical composition comprises  
2 periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid, NH<sub>4</sub>HF<sub>2</sub>, or a mixture thereof.

1        5. The process of claim 1 wherein the secondary oxidizer comprises hydrogen  
2 peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1        6. The process of claim 1 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1        7.     The process of claim 1 further comprising a second polishing operation  
2     comprising the steps of:

3                providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4     pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5     the pH of the composition is between about 3 to about 12;

6                movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7     psi pressure on the substrate and with the second composition under conditions that tungsten is  
8     removed at a rate different than the removal of the dielectric material.

1        8.     The process of claim 7 wherein the second chemical mechanical polishing  
2     composition comprises ammonium persulfate, a pH adjusting compound to adjust the pH of the  
3     composition, and optionally an abrasive, wherein the pH of the composition is between about 3  
4     to about 12.

1        9.     A method for chemical mechanical polishing of tungsten comprising:

2                providing a semiconductor substrate comprising on one face tungsten and a dielectric  
3     material;

4                providing a chemical mechanical polishing composition comprising between about 0.5%  
5     and about 10% periodic acid, between about 0.1% and about 10 % of a secondary oxidizer, a pH  
6     adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the  
7     pH of the composition is between about 4 to about 12;

8                movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9     psi pressure on the substrate and with the composition under conditions that tungsten is removed  
10    at a rate different than the removal of the dielectric material.

1        10.    The process of claim 9 wherein the secondary oxidizer comprises potassium  
2     peroxyomonosulfate, imidazole, malonic acid, or malonamide.

1        11.    The process of claim 9 wherein the chemical mechanical polishing composition

2 comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1           12. The process of claim 9 wherein the chemical mechanical composition comprises  
2 ammonium persulfate, peracetic acid, oxalic acid, NH<sub>4</sub>HF<sub>2</sub>, or a mixture thereof.

1           13. The process of claim 9 wherein the secondary oxidizer comprises hydrogen  
2 peroxide, a perborate, a peroxyhydrate, or a urea hydrogen peroxide complex.

1           14. The process of claim 9 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1           15. The process of claim 9 further comprising a second polishing operation  
2 comprising the steps of:  
3           providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;  
6           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that tungsten is  
8 removed at a rate different than the removal of the dielectric material.

1           16. The process of claim 9 wherein the second chemical mechanical polishing  
2 composition comprises 0.5% and about 10% periodic acid, a pH adjusting compound to adjust  
3 the pH of the composition, and optionally an abrasive, wherein the pH of the composition is  
4 between about 3 to about 12.

1           17. A method for chemical mechanical polishing of copper comprising:  
2           providing a semiconductor substrate comprising on one face copper and a dielectric  
3 material;

4           providing a chemical mechanical polishing composition comprising between about 1%  
5    and about 20% hydroxylamine, hydroxylamine sulfate, hydroxylamine nitrate, or mixture thereof,  
6    between about 0.1% and about 10 % of a carboxylic acid, a pH adjusting compound to adjust the  
7    pH of the composition, and optionally an abrasive, wherein the pH of the composition is between  
8    about 3 to about 12;

9           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
10   psi pressure on the substrate and with the composition under conditions that copper is removed at  
11   a rate different than the removal of the dielectric material.

1           18.   The process of claim 17 wherein the chemical mechanical polishing composition  
2    comprises potassium peroxyomonosulfate, imidazole, malonic acid, or malonamide, and wherein  
3    the second material is a dielectric material.

1           19.   The process of claim 17 wherein the chemical mechanical polishing composition  
2    comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1           20.   The process of claim 17 wherein the chemical mechanical composition comprises  
2    periodic acid, peracetic acid, oxalic acid,  $\text{NH}_4\text{HF}_2$ , or a mixture thereof.

1           21.   The process of claim 17 wherein the secondary oxidizer comprises hydrogen  
2    peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1           22.   The process of claim 17 wherein the chemical mechanical polishing composition  
2    additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3    acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1           23.   The process of claim 17 further comprising a second polishing operation  
2    comprising the steps of:  
3           providing a second chemical mechanical polishing composition comprising an oxidizer, a

4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;

6 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that copper is  
8 removed at a rate different than the removal of the dielectric material.

1 24. The process of claim 17 wherein the second chemical mechanical polishing  
2 composition comprises hydroxylamine or a salt thereof, a pH adjusting compound to adjust the  
3 pH of the composition, and optionally an abrasive, wherein the pH of the composition is between  
4 about 3 to about 12.

1 25. A method for chemical mechanical polishing of aluminum comprising:  
2 providing a semiconductor substrate comprising on one face aluminum and a dielectric  
3 material;

4 providing a chemical mechanical polishing composition comprising between about 2%  
5 and about 12% ammonium persulfate, a pH adjusting compound to adjust the pH of the  
6 composition, and optionally an abrasive, wherein the pH of the composition is between about 2  
7 to about 8;

8 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9 psi pressure on the substrate and with the composition under conditions that aluminum is  
10 removed at a rate different than the removal of the dielectric material.

1 26. The process of claim 25 wherein the chemical mechanical polishing composition  
2 comprises potassium peroxyomonosulfate, peroxyomonosulfuric acid, imidazole, malonic acid, or  
3 mixture thereof.

1 27. The process of claim 25 wherein the chemical mechanical polishing composition  
2 comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1           28. The process of claim 25, wherein the chemical mechanical composition comprises  
2 periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid, NH<sub>4</sub>HF<sub>2</sub>, or a mixture thereof.

1           29. The process of claim 25 wherein the chemical mechanical polishing composition  
2 comprises hydrogen peroxide, a perborate, a peroxyhydrate, or a urea hydrogen peroxide complex.

1           30. The process of claim 25 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1           31. The process of claim 25 further comprising a second polishing operation  
2 comprising the steps of:

3                 providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4 pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5 the pH of the composition is between about 3 to about 12;

6                 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
7 psi pressure on the substrate and with the second composition under conditions that alumina is  
8 removed at a rate different than the removal of the dielectric material.

1           32. The process of claim 25 wherein the second chemical mechanical polishing  
2 composition comprises ammonium persulfate, a pH adjusting compound to adjust the pH of the  
3 composition, and optionally an abrasive, wherein the pH of the composition is between about 3  
4 to about 12.

1           33. A method for chemical mechanical polishing of a substrate comprising:

2                 providing a semiconductor substrate comprising on one face a metal and a dielectric  
3 material;

4                 providing a chemical mechanical polishing composition comprising between about 0.1%  
5 and about 10% of ammonium hydroxide, NH<sub>4</sub>HF<sub>2</sub>, peracetic acid, or mixture thereof, a pH

6       adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein the  
7       pH of the composition is between about 2 to about 13;

8           movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9       psi pressure on the substrate and with the composition under conditions that metal is removed at  
10      a rate different than the removal of the dielectric material.

1       34.     The process of claim 33 wherein the chemical mechanical polishing composition  
2       comprises potassium peroxyomonosulfate, peroxyomonosulfuric acid, imidazole, malonic acid, or  
3       malonamide.

1       35.     The process of claim 33 wherein the chemical mechanical polishing composition  
2       comprises at least one of potassium iodate, potassium periodate, or lithium periodate.

1       36.     The process of claim 33, wherein the chemical mechanical composition comprises  
2       periodic acid, peracetic acid, oxalic acid, citric acid, lactic acid, or a mixture thereof.

1       37.     The process of claim 33 wherein the chemical mechanical polishing composition  
2       comprises hydrogen peroxide, a perborate, a peroxhydrate, or a urea hydrogen peroxide complex.

1       38.     The process of claim 33 wherein the chemical mechanical polishing composition  
2       additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3       acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, or salts thereof.

1       39.     The process of claim 33 further comprising a second polishing operation  
2       comprising the steps of:

3           providing a second chemical mechanical polishing composition comprising an oxidizer, a  
4       pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein  
5       the pH of the composition is between about 3 to about 12;

6           movably contacting the substrate face with a pad exerting between about 0.1 and about 9

7       psi pressure on the substrate and with the second composition under conditions that the metal is  
8       removed at a rate different than the removal of the dielectric material.

1           40.      A method for chemical mechanical polishing of copper comprising:  
2                  providing a semiconductor substrate comprising on one face copper and a dielectric  
3       material;

4                  providing a chemical mechanical polishing composition comprising between about 0.1%  
5       and about 10% ammonium persulfate, at least one of a secondary oxidizer, an organic acid, or a  
6       chelating agent, a pH adjusting compound to adjust the pH of the composition, and optionally an  
7       abrasive, wherein the pH of the composition is between about 3 to about 8;

8                  movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9       psi pressure on the tungsten substrate and with the composition under conditions that tungsten is  
10      removed at a rate different than the removal of the dielectric material.

1           41.      The process of claim 40 wherein the secondary oxidizer comprises potassium  
2       peroxymonosulfate, imidazole, malonic acid, potassium iodate, potassium periodate, lithium  
3       periodate, or malonamide, periodic acid, oxalic acid, and wherein the second material is a  
4       dielectric material.

1           42.      The process of claim 41 wherein the chemical mechanical polishing composition  
2       additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3       acid, lactic acid, succinic acid, tartaric acid, citric acid, or salts thereof.

1           43.      A method for chemical mechanical polishing of tungsten comprising:  
2                  providing a semiconductor substrate comprising on one face tungsten and a dielectric  
3       material;  
4                  providing a chemical mechanical polishing composition comprising between about 2%  
5       and about 20% hydroxylamine, between about 0.1% and about 10 % of a secondary oxidizer, a  
6       pH adjusting compound to adjust the pH of the composition, and optionally an abrasive, wherein

7 the pH of the composition is between about 7 to about 12;  
8 movably contacting the substrate face with a pad exerting between about 0.1 and about 9  
9 psi pressure on the substrate and with the composition under conditions that tungsten is removed  
10 at a rate different than the removal of the dielectric material.

1           44. The process of claim 43 wherein the secondary oxidizer comprises potassium  
2 peroxymonosulfate, peroxymonosulfuric acid, imidazole, malonic acid, or malonamide.

1           45. The process of claim 43 wherein the chemical mechanical polishing composition  
2 comprises at least one of potassium iodate, periodic acid, peracetic acid, potassium periodate,  
3 NH<sub>4</sub>HF<sub>2</sub>, or lithium periodate.

1           46. The process of claim 43 wherein the secondary oxidizer comprises hydrogen  
2 peroxide, a perborate, a peroxyhydrate, or a urea hydrogen peroxide complex.

1           47. The process of claim 43 wherein the chemical mechanical polishing composition  
2 additionally comprises an organic acid selected from the group consisting of gluconic, malonic  
3 acid, lactic acid, succinic acid, tartaric acid, citric acid, oxalic acid, citric acid, or salts thereof.